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HYDROLOGICAL FACTORS FOR REGIONAL MANAGEMENT PLAN OF PERMANENT PRODUCTION FOREST MANAGEMENT IN MUSI RAWAS AND MUSI BANYUASIN*

by
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ABSTRACT

The study was conducted in Musi Rawas and Musi Banyuasin area. This area is choosen because it is one of the pilot project in which the Permanent Production Forest Management (PPFM) tries a system as an opposed to the concessions system .

The purpose of the study are to apply the PPFM system for plantations and Natural Forest within Sub-region of South Sumatera, preparation of an optimal management plan to PPFM, and development of management information system.

Hydrological factor is one of the factors that will support the development of the PPFM system. Two aspects have been discussed in this study, i.e. (1) types of climate based on rainfall data of stations within the area, (2) water balance based on data analysis of sub-catchments, and (3) runoff in sub-catchments.

The study shows that the type of climate based on Oldeman is between B1 and B2 which indicates 7-9 consecutive wet months with 0-4 dry months, while the water balance in most of the catchments shows that there are 0-2 months shortage of water during July to September but most of the shortages are still being compensated by the other months.

INTRODUCTION

This study is a continuation of the previous study with an expanded area and activities which emphasizes sustainable forest management in South Sumatera. The first study was the establisment of Industrial Forest Plantation in Musi watershed in South Sumatera. The problem in this area is to find out a method of Forest

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Management that can be used as a sustainable one, meaning to minimize the impact to the environment. According to Darmakusuma (1996), there are two basic impacts in the establisement of Industrial Forest Plantation (IFP), physical and socio-economic impacts. The physical impact can be described by the erosion and hydrological conditions. Thornthwaite and Mather (1957) explained a method to compute water balance in an area, that can be applied to catchments. The study has taken into consideration the latest development regarding sustainable forest management, the creation of permanent areas of production forest and dividing them into management units, PPFM's (Permanent Production Forest Management) as opposed to consessions. The Information of PPFM's is described in detail in the Ministry of Forestry's Regulation No.200/KPts-II/1991.

Thus the study is to focus on the development of the methodology for the identification of PPFM's rather than the process of actually establishing them. Several data are needed, and one of them is the hydrological condition. For carrying out the work in accordance with the objective, an area covering the Musi Rawas and Musi Banyuasin districts, north of the Musi River has been selected.

METHODOLOGY

Study Area

The identiffication for PPFM's area and catchment boundaries are based on SPOT-XS satelite imagery maps in the scale of 1:50000, because it is suitable to select areas for forest production and to be a basis for the management planning including planning for PPFM.

Data Collection

a) RePPProt data are used for the analysis because it consists of several factors such as landuse, topography, rainfall, etc. in Sumetera.
b) Climatological data were collected from the Agency for Meteorology and Geophysics (1980-1989) and from the Provincial Officies in Palembang (1989-1993). Several stations are used, i.e.: Talang Betutu, Sekayu, Lubuk Linggau, Surolangun (Rawas), Bayung Lencir, and Muara Enim. Those data are used for identifying climate types and to compute the water balance in the catchment areas.
c) Field work was carried out in this study to overview the physical conditions of the area.

Data Analysis

Climate type which is used is based on Oldeman classification, where wet-month is a month with more than 200 mm of rainfall and dry-month is a month with less or equal to 100 mm of rainfall. Analysis of climate types is determined by the consecutives of wet and dry month.

Water balance in the sub-catchment is calculated based on precipitation and evapotranspiration data, using Thornthwaite Formula (Kijne, 1974) as follows,

$Ep_x = 16(10T/I)^a$ .... (1)

$Ep = f \times Ep_x$ .... (2)

where, Ep = Potential Evapotranspiration (mm)

Ep_x = Potential Evapotranspiration (mm/month), one month = 30 days with a day-length of 12 hours

T = Average monthly temperature (°C)

I = Annual Heat Index, the sum of monthly heat-index or $i = (T/5)^{1.514}$

a = $0.000000675\ I^3 - 0.000077\ I^2 + 0.01792\ I + 0.49239$

f = Correction factor of mean possible duration of sunlight for the latitude

Runoff of each sub-catchment is determined by using "media elevation" and "water holding capacity".

PHYSICAL CONDITION OF THE AREA

1. Physiography

The study area is situated in South Sumatera (Musi Rawas - Musi Banyuasin) within the physiographic unit of the eastern plains and hills areas of Sumatera and also mountainous area. Most of the area is located on the alluvial plain of the eastern part and along the northern part of the Musi River, with an altitude ranging from 0 - 50 meters above mean sea level.

The hilly part lies in the southwest of Bayung Lencir with an altitude ranging from 50-150 meters above mean sea level. The western part of the area is mountainous with an altitude ranging from 100 - 2200 meters above sea level covering about 15% of the project area.

2. Geology and Geomorphology

The South Sumatera area according to Bemmelen (1970) comprises the alluvial plain of the east coast, the tertiary foreland and sub-Barisan depression. Most of the area consists of Neogene Formations. Other geological formations commonly found here are: quartenary volcanics, neogene without cover of quartenary sediments, and pretertiary and old andesites.

3. Climate

The types of climate in Musi Rawas and Musi Banyuasin are analysed by using the Oldeman method, climatological data ara based on the stations in the Musi Rawas - Musi banyuasin area. The types of climate in this area are mainly B1 and B2 according to Oldeman's classification.

RESULT AND DISCUSSION

Result and discussion about the hydrological condition in the area is discribed in three points i.e.: (1) climate types, (2) water balance, and (3) runoff

1. Climate Types

In order to determine climate types, the Oldeman classification is used. Looking at the hydrological map (Figure 1), the types of climate in the study area are mainly B1 and B2. The B1 type is characterized by 7-9 consecutives wet-months and 0-1 dry-month, while the B2 type is characterized by 7-9 consecutives wet-months with 2-4 dry-months. The 7-9 consecutives wet-months will support the dry-months, and based on precipitation data (Table 1) and evapotranspiration data (Table 3) it seems the storage of water is in a good condition.

2. Water Balance

In the evaluation of water balance, several data are needed, such as precipitation, temperature, and evapotranspiration. Those data were derived from several station and then drawn into a map.

Precipitation

Average monthly rainfall and number of rainy days for Musi Rawas and Musi Banyuasin are presented in Table 1.

Table 1 : Average Monthly Rainfall (mm) and Number of Rainy Days (1980 -1993) Musi Rawas and Musi Banyuasin, South Sumatera Province

No of STAT	Elev (m)	Name of Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
91 A	12	Talang Betutu (Palembang)	227	250	373	233	220	210	145	44	90	167	297	344	2641
			17	17	20	16	15	6	8	13	8	13	12	18	163
210	9	Sekayu	259	285	359	273	218	134	79	112	126	190	331	332	2698
			17	17	21	19	14	10	7	9	11	12	20	19	176
210 J	130	Lubuk Linggau	321	229	313	250	204	132	158	141	147	199	333	326	2753
			11	9	14	13	12	7	6	5	8	10	15	12	122
188	100	Surulangun	272	222	256	293	240	120	186	115	120	249	296	373	2742
			19	10	20	19	15	9	11	8	10	17	18	19	175
189	2	Bayung Lencir	239	224	276	211	209	116	103	74	72	157	301	321	2308
			16	14	12	11	15	9	8	7	6	6	9	13	128
204	15	Muara Enim	412	257	348	331	191	115	112	176	260	296	296	327	2944
			18	11	15	15	8	8	6	10	14	13	13	16	141

Source : 1) Meorological and Geophysic Agency, Jakarta (1991)
2) BMG, Balai Wilayah II, Climatology Station Office Palembang, South Sumatera Province
3) Calculation

According to Oldeman there are some dry months (< 100 mm/month) in the areas. Table 1 shows that most of the areas have enough rainfall because the dry month can be compensated by the wet months (<200 mm).

Temperature

Temperature data of Musi Rawas and Musi Banyuasin areas were collected from the same stations in term of rainfall. The figure of the temperature can be seen in Table 2.

Table 2 : Average Monthly Temperature (°C) in Musi Rawas and Musi Banyuasin , South Sumatera Province.

Name of Station	Elev (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Talang Betutu (Palembang)	12	26.1	26.3	26.7	27.3	27.4	27.3	26.8	27.2	27.0	27.1	26.5	26.4
Sekayu	9	9	26.6	26.6	26.9	27.2	27.4	27.2	27.2	27.0	27.2	27.2	26.8
Lubuk Linggau	130	26.2	26.2	26.4	26.5	26.8	26.4	26.7	26.2	26.5	26.4	26.0	26.1
Surulangun	100	25.5	25.8	26.2	26.8	26.9	26.8	26.3	26.7	26.5	26.6	26.1	26.9
Bayung Lencir	2	26.2	26.4	26.8	27.4	27.5	27.4	26.9	27.3	27.1	27.2	26.7	26.5
Muara Enim	15	26.2	26.2	26.7	26.9	27.0	26.9	27.1	27.4	26.8	27.0	26.6	26.4

Source : 1) Meorological and Geophysic Agency, Jakarta (1991)
2) BMG, Balai Wilayah II, Climatology Station Office Palembang, South Sumatera Province
3) Calculation

Looking at Table 2, it can be decided that the monthly temperature in the area during a year are more or less in average between 25.6 ^{0}C to 27.5 ^{0}C. The fluctuation of monthly temperature over the year is very low, about 1.9 ^{0}C.

Evapotranspiration

Potential evapotranspiration was calculated using the Formula 2 of Thornthwaite (Kijne, 1974), which has been mentioned earlier.. Based on the formula of Thornthwaite, the result of evapotranspiration calculation can be seen in Table 3.

Table 3 : Potential Evapotranspiration (mm) in Musi Rawas and Musi Banyuasin, South Sumatera Province.

Name of Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Talang Betutu (Palembang)	130	121	141	150	157	150	144	153	143	150	136	136
Sekayu	139	126	146	147	156	152	152	152	143	152	147	144
Lubuk Linggau	133	120	137	135	145	133	142	133	135	137	126	131
Surulangun	123	114	133	140	147	140	135	142	135	141	127	128
Bayung Lencir	132	122	144	153	159	153	146	155	145	152	137	137
Muara Enim	132	119	142	142	149	142	151	157	140	149	136	136

Source : Calculation

Evaluating Table 3, it shows that the potential evapotranspiration in the area of Musi Rawas and Musi Banyuasin are mostly ranging from 114 to 159 mm/month with an average of 114 mm/month. It means there are no significant differences between wet and dry seasons.

Water Balance

Evaluating Table 1 and Table 3, water balance at the project area could be drawn as presented in the hydrological map (Figure 1). Each station shows the annual water balance based on the Thiessen Polygon area. According to the available climatic data of Musi Rawas and Musi Banyuasin, there are about 0-4 months deficit of water at the stations in the surrounding area (between June to September). Based on the storage of water, Bayung Lencir and Palembang stations which are located in the near by coastal area have less storage as compared to the other stations in the upper area (Sekayu, Surolangun, Muara Enim, and Lubuk Linggau).

3. Runoff

The runoff estimation is based on Thornthwaite and Mather method, and it is applied to sub-catchment level. There are several sub-catchments in Musi Rawas - Musi Banyuasin area, i.e.: Beliti, Lakitan, Rawas,Pigi, Batang Harilako, Lalang, and Calik Banyuasin. Land use map scaled to 1:250000 and climatic map scaled to 1:500000 of Musi Rawas - Musi Banyuasin area are used for the calculation of sub-catchment runoff.

• *Median Elevation* is the average elevation or contour line that splits the area of sub-catchment into two equal parts, one with an altitude above and the other with an altitude below the choosen contour line. The median elevation for each sub-catchment are shown in Table 4.

• *Water Holding Capacity* (WHC) is the maximum capacity of soil based on the texture to keep a volume of water under a certain land use type. The types of land use which cover the area consist of forest, unproductive land use, agriculture and other uses, while the soil texture in the area is mainly clay-loam. Using the provisional water holding capacities with different combinations of soil and vegetation of Thornthwaite (Appendix 1), the WHC of each sub-catchment can be calculated and the result is shown in Table 4.

Table 4 Hydrological Condition in Musi Rawas and Musi Banyuasin

Sub-Catchment	Area (km^2)	Median Elevation (mm)	Annual Perception (mm)	Annual Evapotrans-piration (mm)	Annual Runoff (mm)	Water Holding Capacity (mm)
1. A. Calik Banyuasin	14010.0	10	2629	1716	924	330
2. A. Lalang	8147.5	5	2328	1732	653	360
3. A. Batang Harilako	3537.5	25	2470	1737	763	330
4. A. Lawas	6155.0	75	2741	1639	1049	360
5. A. Lakitan	2672.5	55	2754	1705	1048	330
6. A. Beliti	1780.0	200	2753	1531	1202	275
7. A. Pigi	687.5	60	2753	1698	1049	250

Source : 1) Climatic Map of Musi Rawas and Musi Banyuasin, scale 1:500000
2) Forest Vegetation and Land Use Map, scale 1:250000

Table 4 shows that based on the water holding capacity (WHC), the storage of water in the soil are between 250-30 mm in a meter of depth. It means that there are about 25% - 36 % of water storage which can be used if the runoff is not enough for several usages.

The three factors in hydrology, i.e.: type of climate, water balance, and runoff a coincide with the water storage in this PPFM study. From the field work as an overview of the physical condition, several creeks and rivers are still having water during the dry-season (July-August) with forest cover about 50% of the whole area.

CONCLUSIONS

1. The results of this study shows that the hydrological condition based on storage of water is in a good stage, because from each climatic station the amount of water holding capacity (WHC) are more then 100 mm/month. The dry months can be supported by the wet months in the year. These figure indicates that the forest condition in the area is still in a good management plan.

2. The hydrological condition can be a suporting data for the benefit of the PPFM's establishment planning, so that it can minimized the problem of impact in the area, especially in term of the water storage condition.

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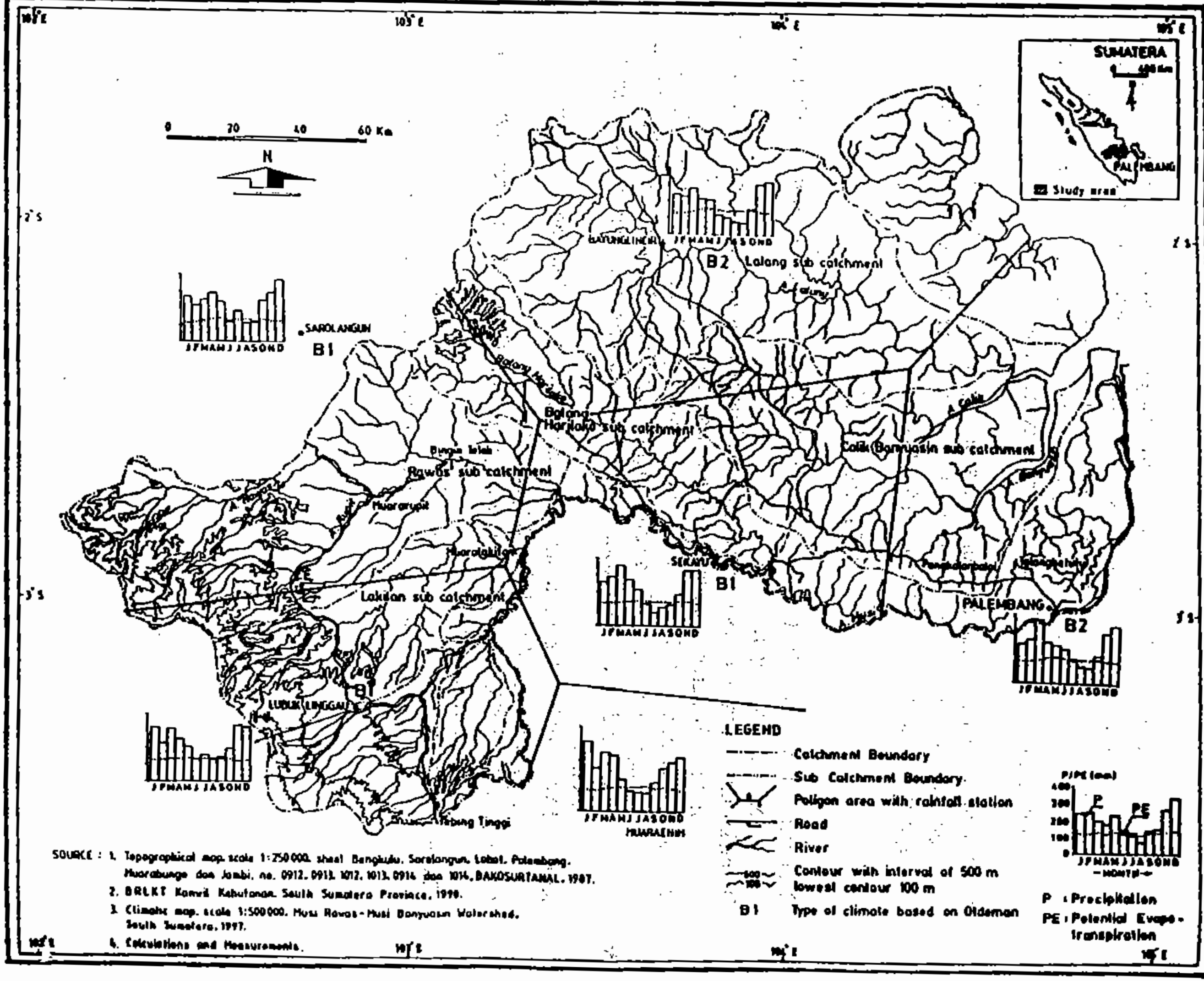

Figure 1. Hydrological Map Musi Rawas - Musi Banyuasin Watershed, *South Sumatera*

Provisional water holding capacities with different combinations of soil and vegetation

Soil Type	Available Water mm/m	Root Zone m	Applicable Soil Moisture Retention Table mm
Shallow-rooter crops (Spinach, peas, beans, teets, carrots, etc)			
• Fine sand	100	.50	50
• Fine sandy loam	150	.50	75
• Silt loam	200	.62	125
• Clay loam	250	.40	100
• Clay	300	.25	75
Moderately deep-rooted crops (Corns, cooton, tobaco, cereal grains)			
• Fine sand	100	.75	75
• Fine sandy loam	150	1.00	150
• Silt loam	200	1.00	200
• Clay loam	250	.80	200
• Clay	300	.50	150
Deep-rooted crops (Alfalfa, pastures, shrubs)			
• Fine sand	100	1.00	200
• Fine sandy loam	150	1.00	150
• Silt loam	200	1.25	250
• Clay loam	250	1.00	250
• Clay	300	.67	200
Orchards			
• Fine sand	100	1.50	150
• Fine sandy loam	150	1.67	250
• Silt loam	200	1.5	300
• Clay loam	250	1.00	250
• Clay	300	.67	200
Closed mature forest			
• Fine sand	100	2.50	250
• Fine sandy loam	150	2.00	300
• Silt loam	200	2.00	400
• Clay loam	250	1.60	400
• Clay	300	1.17	350

Source : Thorthwaite and Mather (1957)